

Seek Eagle's experts make certain bombs, missiles, and pods play nicely with the aircraft that carry them into battle.

By Aaron M. U. Church, Associate Editor

Eglin's Middle Men

Samuel Burnham from USAF's Seek Eagle office configures a horn antenna before testing a Litening pod on an F-15 at Eglin AFB, Fla.

USAF photo

An F-16CJ carrying two GBU-38 JDAMs and an AGM-88 HARM completes air refueling before an air strike on Syria. Seek Eagle experts were able to provide USAF with safe parameters to fly the configuration.

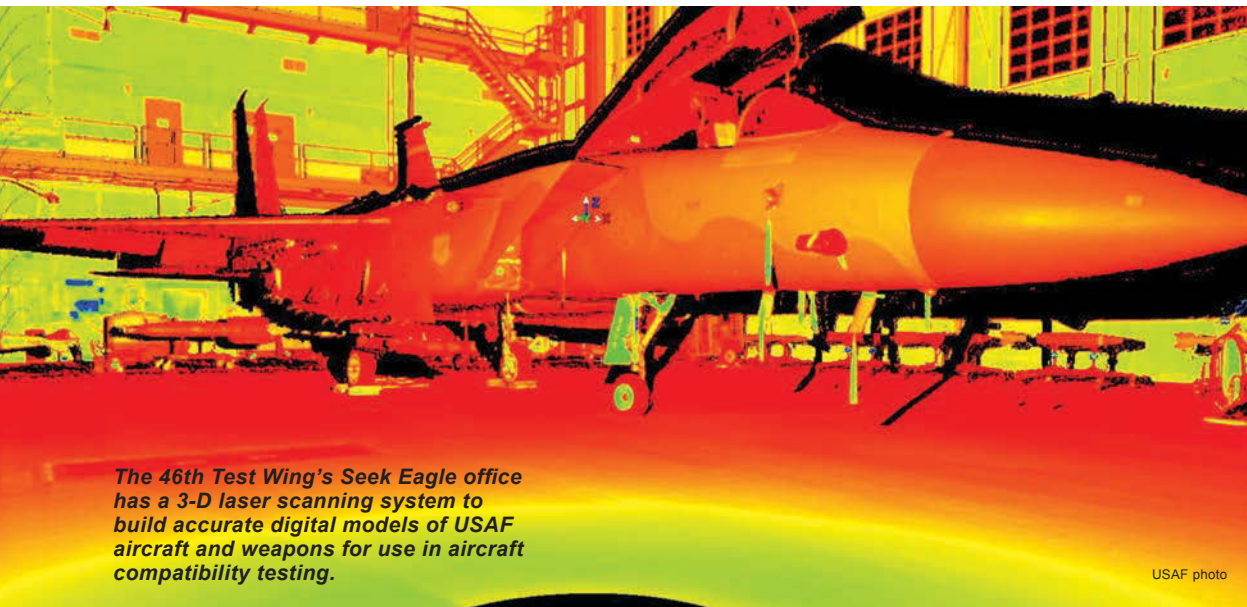


In the business of air combat, there are aircraft, and there are weapons, and most of the time they don't come neatly packaged together. This is where the Air Force's Seek Eagle office at Eglin AFB, Fla., comes in.

"Aircraft stores compatibility is what we're about," Seek Eagle Technical Director Dale Bridges briefed to *Air Force Magazine* during a reporter's visit there in June. Anytime USAF wants to add something external onto an aircraft—whether as mundane as a baggage pod or as complex as a guided smart weapon—every aspect must be checked for symbiotic operation. Both the aircraft and the add-on must be able to do their intended job without damaging or destroying them.

In the high-Mach, high-G, and electronically charged atmosphere of a modern fighter aircraft, a lot of things can cause debilitating or even catastrophic problems. "We've got guys who buy airplanes, build airplanes, we've got guys who build bombs and buy bombs, and sometimes they talk to each other," quipped Mike Johnson, principal technical advisor. "We kind of act as a middle man," he observed, and often it requires a fair bit of "head scratching."

Seek Eagle is made up of about 75 Air Force civilians—mostly engineers and a few mathematicians, complemented by 75 civilian contractors. "The vast majority are very technical—a lot of advanced degree folks, a lot of Ph.D.s," noted Bridges. The



The 46th Test Wing's Seek Eagle office has a 3-D laser scanning system to build accurate digital models of USAF aircraft and weapons for use in aircraft compatibility testing.

USAF photo



USAF photo

office is organizationally part of Eglin's 96th Test Wing, but is directly funded to ensure weapons can be evaluated, certified, and deployed operationally as efficiently as possible. "They created this office for a reason," said Bridges.

Following a tidal wave of new and increasingly sophisticated weapons during the Vietnam War, the Air Force turned to Seek Eagle as a means of quickly evaluating urgently needed weapons and speed them to the field. "Before they set up [the] Seek Eagle office, they really didn't have control over what work got done when," Bridges explained. Because it has its own budget, technical experts, and resources, Seek Eagle is more nimble and far cheaper than working through industry contracts. "This organization turns quickly—it's a lifesaver, and that right there earns its pay every time," Bridges said.

On the developmental side, Seek Eagle is responsible for aircraft stores compatibility on Air Force fighter platforms, including the F-15, F-16, F-35, and A-10, and often lends its expertise to bomber programs such as the B-1, B-2, and B-52. Seek Eagle's engineers and technical experts cover eight main disciplines and are divided into specialized teams with skills including weapon and aircraft stores fit, ballistics, carriage and release, safe escape, planning software development, and historical weapons data.

NERDS IN THE FIGHT

Seek Eagle's work isn't just about new weapons and stores but also about mixing operational aircraft and weapons in different ways, as was the case during Operation Odyssey Dawn in 2011.

Lockheed Martin photo



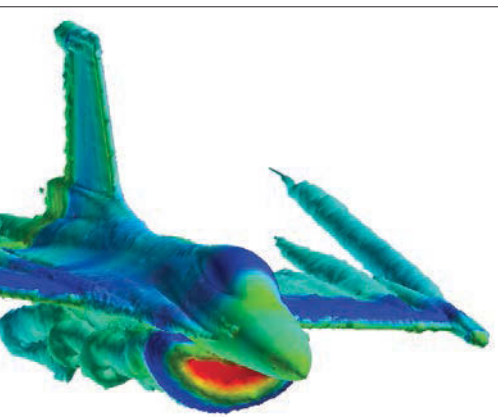
This F-35 graphically displays the vast combination of weapons loadouts possible on a modern combat aircraft. Seek Eagle must evaluate each of them for cross-compatibility, safety, and mission effectiveness.

USAF photo

F-16CJs tasked to suppress Libyan air defenses were also striking ground targets, often in dense urban areas. Planners were keen to limit collateral damage and called on Seek Eagle to see if the F-16's loadout could be altered without wrecking its stability. The jets were flying mixed loads—a single High-speed Anti-Radiation Missile for suppression of enemy air defenses and a single 2,000-pound Joint Direct Attack Munition for ground targets. "They needed, as fast as they could get it, a 500-pound JDAM in place of that 2,000 pounder," recalled Ted Welch, principal technical

advisor. No flight testing was required, so the office's technical team ran their calculations to evaluate the weight, balance, and flutter risks to ensure the "aircraft wasn't going to oscillate in a bad way," said Welch.

Within five days, the team identified several potential pitfalls, but recommended clearing the configuration for flight within specific guidelines. The F-16 system program office took the recommendation, and 97 percent of the Air Force F-16 sorties over Libya from that point on "were the loadings given to them by that five days of work," Welch



This Seek Eagle-developed 3-D F-16 computer model shows the magnitude of vortices and air pressure (shown by color) over the aircraft's surface during a maneuver.



said. "That's why we're here and have our own budget. ... The warfighter can call and we execute."

The Air Force has invested a great deal over the years to build a team of experts and a set of analytical capabilities that are "second to none anywhere in the world," Welch stated.

Seek Eagle's reputation, however, wasn't built overnight. "Our guys have been around for a while, so weapons and tactics officers in the units know them by name, and the relationship is awesome. ... They know we'll jump when they call," he said.

Getting It Right From the Get-Go

Seek Eagle often saves industry dollars and headaches by bringing to bear its expertise on compatibility even before a weapon is built, Technical Director Dale Bridges told *Air Force Magazine*. "We see every aircraft, we see every store" coming through certification, and "everything we've learned, we can apply" to help industry avoid the mistakes and pitfalls of previous programs, he said.

With its models and historical data, Seek Eagle is able to tell industry, "Here's your box—mass, size, properties, and if you get outside this box, your program's going to get very expensive," stressed Bridges.

A prime example is Raytheon's next generation Advanced Medium-Range Air-to-Air Missile, the AIM-120D. It just completed operational testing earlier this spring. "When they first started building the missile, it was going to be too heavy," said Seek Eagle Principal Technical Advisor Ted Welch. The existing AIM-120 had already been thoroughly tested, but if the company exceeded certain limits—especially important for the F-16—they would have to "flutter-flight test the whole book, which is years of effort," Welch noted.

As a result of Seek Eagle's analysis and expertise, Raytheon's engineers were able to get the missile's weight down and "avoided a lot of flutter testing by working together," he said.

Sometimes companies take the advice and "sometimes they don't," Welch conceded, but when they do, "we've saved them a lot of time and money, and they get a good product to the warfighter in the end."

USAF photo by Ilka Cole



MAKING MODELS

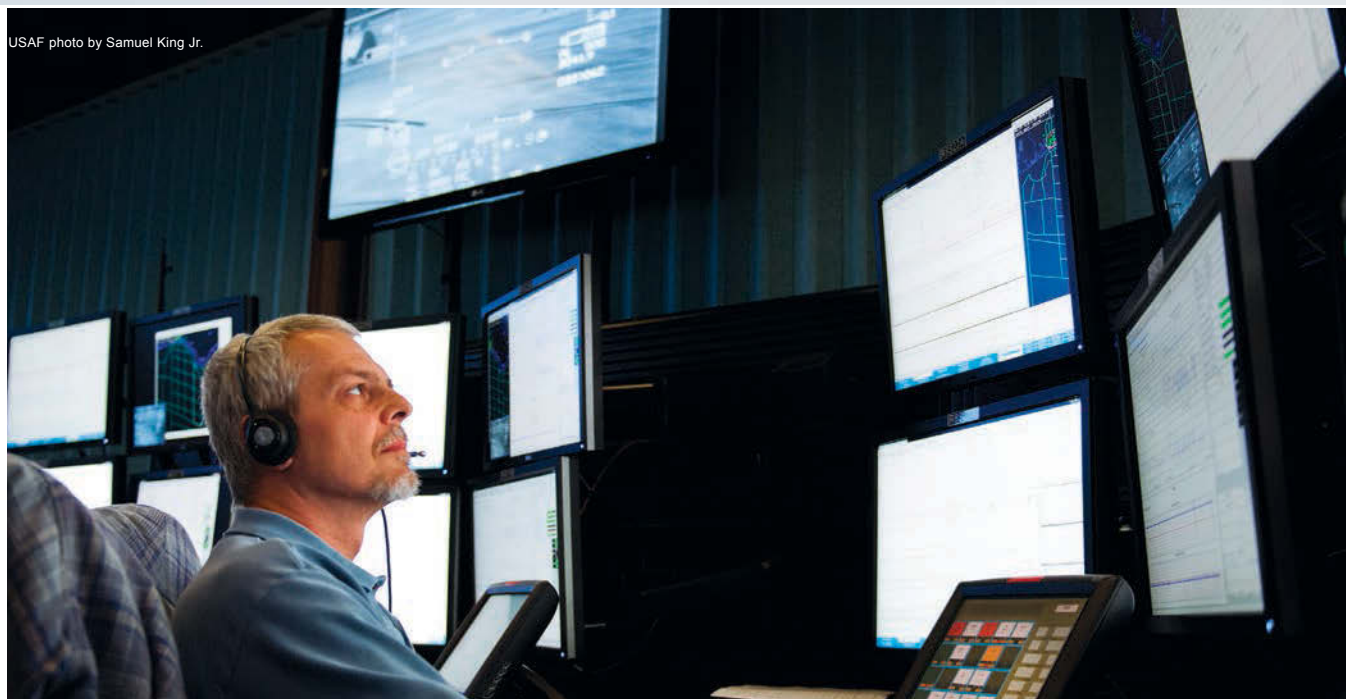
No part of this work is trivial, and seemingly innocuous factors like whether a weapon physically fits on the aircraft sends industry and the Air Force back to the drawing board. "It's amazing how often fit problems have occurred in the past," Welch said, pointing out a cruise missile evaluated for fit on the F-15E as a recent example. The stores loader raises the missile into place using a custom pallet that, in the F-15's case, would gouge the aircraft's main tire.

Since there is little that can be done for already fielded weapons, Seek Eagle

David Senter, a Seek Eagle ordnance equipment specialist, steadies a JASSM at the Mass Properties Measurement Facility at Eglin.

tries to work with industry ahead of time. At a minimum, the office likes to fit-check future weapons using computer models of the airframes, "so if you do find a problem, you can change your outer mold line," said Welch.

Accurate computer modeling and simulation saves vast sums of time and money—not to mention hardware damage—and Seek Eagle has developed some of the best tools in the industry.



USAF photo by Samuel King Jr.

James Dubben monitors the beginning of a flutter test from the Central Control Facility at Eglin, checking to make sure aircraft wing vibration is within safe limits, considering airspeed, altitude, G-force, and payload.

“We have computerized physical fit, which is pretty state-of-the-art stuff,” Bridges explained. In the case of the F-15, it highlighted the problem without ever ramming a pallet into a jet. “We do a lot of this stuff ... before we even touch the actual hardware, which saves a lot of time and money—that’s the name of the game,” he added.

The office recently acquired two 3-D laser scanners, greatly enhancing Seek Eagle’s ability to create accurate and useful computer representations. The large volume scanner can map an entire

aircraft to the subtlest contour, and the handheld unit is perfect for scanning weapons.

Welch said, “In our day and age, almost everything that is produced is proprietary”; the Air Force would need to get industry permission to disseminate and share representations of their products. However, “if we laser scan those things and build a model ... and not tie it back to the original proprietary data, we own that,” Welch explained. Unlike the mismatched and often inaccurate industry-supplied aircraft and weapon models, Seek Eagle now generates its own. “We can do a picture of [a Lockheed Martin] F-16, and it’s got a Boeing JDAM, a Northrop Grumman targeting pod, a Raytheon missile,” and Seek Eagle can distribute it to any agency or industry partner that needs it, Welch noted.

For the future Long-Range Standoff missile competition, Seek Eagle is doing exactly that. “For LRSO, you have four competitors and of course the owners of those aircraft don’t really want to share,” Welch pointed out. “We can give them the aircraft models and pylons, and we’ve done that, ... and it helps them come up with a better design quicker.”

The team has scanned everything from the B-2 bomber to a German air force Tornado strike aircraft. As part of NATO’s extended nuclear deterrent, the Panavia Tornado IDS will need to be cleared to carry the upgraded B61 Mod 12 tactical nuclear weapon. Neither the Air Force Nuclear Weapons Center nor the Germans “have a model of that aircraft,” said Welch, so the team paid a visit to the Luftwaffe’s Tornado training unit, conveniently located

An F-35 fires an AIM-120 air-to-air missile over a military test range in California. Seek Eagle provided the missile makers data that allowed the company to keep the weapon's weight down, thus avoiding time-consuming and expensive flutter-flight testing.

Lockheed Martin photo

at Holloman AFB, N.M. Models generated from one of the aircraft in New Mexico will now be used in testing and certification of the life-extended B61.

FLUTTER AND FLUID DYNAMICS

Scanning static aircraft is really only the most basic modeling and simulation work Seek Eagle does. Evaluating the stress loads, aerodynamic forces, and electromagnetic fields modern aircraft and weapons exert on each other requires “a lot of high-tech stuff,” said Bridges. Certain aircraft, especially the F-16, are susceptible to potentially damaging vibrations known as aerodynamic flutter. Hanging fuel tanks, bombs, missiles, and targeting pods on aircraft wings causes them to flex and move, and “it alters the behavior quite a bit,” explained subject matter expert Vin Sharma.

Different external configurations change the aerodynamic characteristics of the aircraft affecting stability and control, and the added mass exerts various loads and stresses on the airframe—all of which must be validated for safety. The data Seek Eagle gleans makes its way into everything from flight manuals and maintenance instructions to weapon delivery software produced in-house.

Every combination would ideally undergo full flight testing, but the number of possible loadouts and aircraft is staggering, making it budget and time prohibitive. “I’ve got 72,000 possible different combinations, ... and the boss says, ‘Great, I’m going to let you go test three of them,’” said Johnson. Picking the most valuable configurations to fly with the neighboring 40th Flight Test Squadron, or other test units, is a “heavy challenge,” Johnson admitted, but his biggest task is designing “simulations

that will hopefully reduce the amount of testing that we need to do.”

Building a solid understanding of an aircraft’s behavior and developing accurate models requires years of effort, and the amount of data is daunting. Seek Eagle is gearing up for the F-35 and “we’re going to be working on that for a few years here before we’re anywhere near the fidelity of an F-16,” Sharma, who is working on the F-35 models, said. Modern computing has enabled the team to turn myriad mathematical equations into an animated, visual representation of airflow around the aircraft to virtually “fly” the aircraft using computational fluid dynamics. “It’s only with the advances in computers that we’re able to take advantage of those formulations and we’re still not there, but we’re close,” said Sharma. These simulations allow Seek Eagle to analyze the aircraft’s behavior under dynamic conditions, because “when you execute a maneuver, the flow is extremely complex” and can “cause all kinds of problems for stability,” he said.

Even modern computers have trouble digesting and processing something as complex as the flight characteristics of a loaded F-35, though. “To analyze a large structure that has millions of degrees of freedom takes quite a bit of time,” explained Sharma. Each configuration can take as much as 20 minutes and at that rate “we can’t afford to run 20,000 configurations,” he said. Instead of dealing with all the variables at once, his team decided to break the jet into smaller pieces, “analyze each component separately, and then put them together.”

Using this “component mode synthesis” reduced the amount of time required to flutter-test a configuration by as much as 40 times. “Rather than 20 minutes, we can get the job done in 20 seconds. ... We’ve proven it,” Sharma said.

LIGHTNING LEARNING

Figuring out how to extrapolate answers from the available data is important, too, especially when it comes to the F-35. Since it’s a joint service program with three different variants, “they may go do a test on the carrier variant” rather than the Air Force’s F-35A, and Seek Eagle has to find a way to translate and use the data, said Johnson. Adverse interactions can be electrical, as well as physical, and he faces similar challenges dealing with electromagnetics.

Almost everything on the F-35 operates on the electromagnetic spectrum—from fly-by-wire flight controls to integrated sensors. So do most of the smart weapons,

targeting pods, and electronic warfare stores the Air Force plans to fly on the jet. “They [produce] a lot of radio frequency radiation,” Johnson said, and “our job is to determine if they will play nicely” together in an operational environment.

For example, GPS guided weapons like the Joint Direct Attack Munition rely on satellite data links to find and hit their targets. “If the airplane is interfering with that in any way, the bomb will come off and go stupid,” said Johnson. Some systems can generate enough energy to “actually detonate” a weapon inside the aircraft in a worst-case scenario, he warned.

The speed of electrons and the danger and/or expense of physically switching things on, make simulation invaluable. “I can get computers to be smart enough to predict some of this stuff—help me decide if that bomb is going to be safe or do its job in the environment around an airplane, and vice versa,” Johnson explained. For the F-35, he was able to test what effects a lightning strike would have on the aircraft and its systems to see where the current would go, what it could affect, “and do we care?”

As it turns out “we cared,” Johnson said. “We just gave them the bad news: I looked at your baby and it’s ugly,” he chuckled.

As with aerodynamic modeling, electromagnetic models are often used in tandem with testing to predict and validate a result—or even explain something unexpected.

Once energy from a radar, antenna, or sensor “starts to interact with all the metallic parts and angles and bits and pieces of an airplane, it gets these weird contours,” Johnson detailed. “It comes off and goes places you don’t really expect and bounces around in places it probably wasn’t intended to.” This is often difficult to picture.

In terms of visualizing, Seek Eagle benefits from having so many areas of expertise under the same roof—not to mention, just across the street, the 40th FLTS with a flight line of actual F-15s, F-16s, and A-10s. “It’s a really good partnership all around Seek Eagle,” Johnson said, noting that he often borrows models from other teams to build his simulations. “We can all work together putting out the simulation product. ... It’s a fun job,” he said. Working together, Seek Eagle is “able to tell you what will work. We’re also able to tell you some things you’ll not want to go do, like break a wing [or] interfere with instrumentation. ... As a middle man, we’re able to communicate both” weapon to aircraft and aircraft to weapon, he explained. ✦